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The second recorded living coelacanth from north Sulawesi

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Synopsis
A detailed account of the second coelacanth specimen known to have been captured in Indonesian waters is provided.
The account is written in the official format of the Coelacanth Conservation Council's (CCC) inventory of known specimens of the living coelacanth Latimeria chalumnae, and the specimen is herein numbered CCC no. 175.
Morphological measurements and fin ray counts are recorded. A comparison of these measurements and meristic data with those recorded for Comoran specimens of Latimeria chalumnae shows that the present specimen has a similar allometry to L. chalumnae. Ongoing genetic analyses should reveal the depth of divergence between the two known populations of living coelacanths and help determine if this specimen is conspecific with its Comoran counterparts.

Introduction

As first reported in Erdmann et al. (1998) and Erdmann (1999), the initial discovery of a coelacanth specimen in a north Sulawesi, Indonesia fish market on 18 September 1997, and the subsequent capture and preservation of a second specimen from the same area on 30 July 1998, strongly suggest the existence of a Sulawesi population of living coelacanths. Those authors suggested that preliminary morphological examination of the second specimen indicated that the Sulawesi population is the same species as the well-known Comoran population of coelacanths, Latimeria chalumnae (Smith 1939).

The purpose of this paper is to record all relevant details of the second specimen within the established framework of the Coelacanth Conservation Council's (CCC) inventory of known specimens of Latimeria chalumnae (Bruton & Coutouvidis 1991). We also provide a comparison of selected morphological measurements and meristic data from this specimen to those reported for Comoran L. chalumnae by McAllister & Smith (1978). Details of the search for the second Sulawesi specimen, as well as a description of the potential habitat, the fishery which accidentally catches coelacanths, and the current conservation status of the Sulawesi population will be described in a future paper (Erdmann & Caldwell unpublished).

The second Indonesian coelacanth

Below we present the official CCC entry for the second Sulawesi coelacanth specimen, following the format of Bruton & Coutouvidis (1991).

(1) CCC no. 175.

(2) Date and time of capture: 30 July 1998, before dawn. The gillnet in which the specimen was captured was set at 17:30 h on the previous day, and pulled from the water at 6:00 h on 30 July. Calm seas, seven days after the new moon (first quarter).

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(3) Site of capture: Directly offshore from the village of Papindan, Manado Tua island. Latitude/longitude: 1° 38' N, 124° 43' E.
(4) Name of fisherman: Om Lameh Sonatham, 56 years of age, owns and is in charge of the shark gill-net which captured the fish, and he and his son Samuel brought the fish to the first author's house on the morning of 30 July 1998.
(5) Distance from shore at capture: Approximately 250-400 m from shore. The shallow (1-7 m) reef flat here is approximately 150 m wide, eventually sloping to a 50 m wide shelf at 15-20 m depth. From the edge of this shelf the reef slopes steeply to over 1000 m depth.

The shark net is anchored at the edge of the reef flat with a 200 m long rope, and the net itself is approximately 150 m in length.

(6) Depth of capture: Approximately 100-150 m depth. As the net itself is 150 m long, and extends downwards along the reef slope, it is difficult to make a more accurate approximation of the depth of capture.

(7) Bait used: No bait was used. As mentioned above, this specimen was captured with a deep-set shark gillnet. Details of the net are provided in Erdmann (1999).

(8) Weight: 29.2 kg, weighed shortly after death and before freezing.

(9) Length: The specimen was 124 cm TL (tip of snout to tip of epicaudal lobe), and 119 cm SL (tip of snout to posterior terminus of notochord). Table 1 summarizes additional body measurements and meristic data recorded during the initial examination of the specimen, with a comparison of these measurements to those reported in McAllister & Smith (1978). Additional fin ray counts not reported by McAllister & Smith (1978) include: dorsal lobe of caudal fin=24; ventral lobe of caudal fin=21; and epicaudal lobe = 33 fin rays.

The results of the comparison to McAllister & Smith's (1978) measurements indicate that the allometry of the Sulawesi specimen is very similar to that reported for Comoran L. chalumnae. Of the lengths and meristic data measured and proportions calculated, only the proportional lengths of the gular plate and the pectoral fins to the specimen's standard length and the number of fin rays in the left pectoral fin fell outside the reported ranges of McAllister & Smith (1978) for L. chalumnae. Furthermore, the log-transformed regression equation of McAllister & Smith (1978, p. 72) for weight of female specimens, using a TL of 124 cm, predicts a weight of 29.5 kg. This prediction is obviously in close accordance with the measured weight of 29.2 kg. Ongoing analyses of mitochondrial DNA sequences of this specimen and comparison to published sequences of Comoran specimens should soon give a clearer indication of the depth of divergence between these two populations of living coelacanths.

(10) Sex: Female, with three maturing ovarian eggs, each approximately 3 cm in diameter.

A review of the literature available to us suggests that this is the second smallest-sized female coelacanth known with eggs. The only smaller specimen reported with eggs is CCC no. 4, a female of 1.09 m TL that Millot et al. (1978) report as having a number of immature eggs in the ovary. They did not report the size and number of these eggs.

Unfortunately, the eggs began to deteriorate quickly as the specimen thawed, and subsequent injection with formalin may have been too late to fully preserve them. The eggs showed no appreciable structure beyond a solid sphere of yellow yolk and they were considerably smaller than mature L. chalumnae eggs, which typically measure 8.5-9.0 cm in diameter (Millot et al. 1978). Our review of the literature does not reveal a clear distinction between preovulatory oocytes and postovulatory eggs, and their respective sizes. Other reports of female specimens with eggs include: Suyehiro et al. (1982) report a 1.75 m female with around 30 ovarian eggs of maximum diameter 4.5 cm; Millot et al. (1978) report a 1.66 m female with immature eggs up to 2 cm in diameter (specimen C9, CCC no. 10), and a 1.8 m female with maturing eggs of maximum diameter 7 cm (specimen C18, CCC no. 20); Bruton & Coutouvidis (1991) describe a 1.42 m female with 'maturing eggs' (CCC no. 8) but size was not provided; Bruton (1993) reports 59 vitellogenic, 'chicken egg-sized' eggs from a 1.68 m female (CCC no. 154); and Heemstra & Greenwood (1992) mention a 1.64 m female with at least 65 ovarian oocytes, ranging in size from 3-15 mm in diameter (CCC no. 159).

The literature is not clear on the determination of 'maturity' in female coelacanths; the description of the 1.42 m specimen CCC no. 8 as an 'immature female with maturing eggs' (Bruton & Coutouvidis 1991) suggests that presence of ovarian eggs does not indicate maturity. Interestingly, Bruton & Armstrong (1991) predict maturity of L. chalumnae at approximately 1.25 m TL, very close to the size of the present specimen. A more detailed examination of the eggs and reproductive tract of the Sulawesi specimen is clearly warranted.

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Length
Reported range

Table 1. Morphological measurements and meristic data recorded from specimen CCC no. 175, Morphological features are as defined in McAllister & Smith (1978). Lengths are reported to the nearest 5 mm, with the percentage below indicating proportional length of the feature compared to the standard length of the specimen. Reported ranges are only for those specimens above 100 cm SL reported by McAllister & Smith (1978), which ranged from 106.3-162.3 cm SL.

Morphological feature
Number of fin rays Reported range

S,
Head length (to posterior
33 cm
30.7-48.5 cm
of opercular flap)
27.7%
27-33%
ts
th
Head length (to posterior
26 cm
22.8-39.0 cm
of bony operculum)
21.8%
d
Snout length
8 cm
21-26%
4.3-12.6 cm
at
6.7%
4-9%
Upper jaw length
13 cm
9.7-18.8 cm
d
10.9%
9-13%
Lower jaw length
24 cm
25.3-34.5 cm
y
20.2%
n
Gular plate length
19.5 cm
16.4%
19-22%
14.1-24.7 cm
13-16%
C-
Operculum width
7.5 cm
7.4-10.4 cm
6.3%
6-8%
y
Orbital diameter
4 cm
3.4-5.6 cm
e
3.4%

3-4%
Body height
25 cm
25.6-43.8 cm
e
21%
20-30%
First dorsal fin
18 cm
17.6-26.0 cm
15.1%
13-18%
S
Second dorsal fin
22 cm
17.8-29.3 cm
28
27-31
e
18.5%
13-20%
Pectoral fin
29 cm
22.9-33.3 cm
30,3
29-32
24.4%
17-23%
Pelvic fin
20.5 cm
17.2%
19 2-31.2 cm
16-21%
3,33
29-33
Anal fin
22.5 cm
18.9%
16.2-27.2 cm
15-19%
30
28-30
Lateral line scale count
82
76-82
A
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(11) Condition on capture: The fish was still alive when the net was hauled in, and was brought to the home of the first author while alive. The specimen sustained minor injuries from the gill net, including broken fin spines on the first dorsal fin and several lac-

erations with missing scales on the left side of the body. Additionally, the anal/urogenital opening was inflamed and bleeding.

An attempt to revive the fish by pulling it with a rope behind a wooden speedboat to pass water over its gills was partially successful, as the fish resumed fin movements within several minutes of towing. The first author and his wife were then able to swim with the fish for over an hour while shooting several rolls of film. Fin movements observed were as described by Fricke et al. (1987), including both sculling motions with the second dorsal and anal fins in opposition, and 'underwater flying' using the paired pectoral and pelvic fins as stabilizing 'wings' (Figure 1). We also observed occasional movement of the paired fins in the alternately synchronous fashion described by Fricke et al. (1987), while no substantial motion of the caudal fin was noted. The first dorsal fin tended to remain folded against the body, though it was erected several times when the first author's wife approached it closely (Figure 2). During this time the fish tended to roll on to its back, and eventually its fin movements became more erratic and the fins limp. At this point, the fish was transported

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Figure 1. The Sulawesi specimen using its pectoral fins as stabilizing 'wings' while held in a slight current.

via speedboat into the city of Manado, where it was weighed, dissected for tissue samples, and then frozen (Figure 3). The fish survived for almost six hours after being removed from the gill net.

(12) Method of preservation: As described above, this specimen was frozen shortly after death. Prior to freezing, a ventral incision was made in the body cavity for the purpose of tissue sample collection. Replicates of the following tissue samples were taken: heart, liver, white muscle (from area of ventral incision), and gill filaments (from the left gill arches). Replicates of each tissue sample were preserved by the following three methods: storage in liquid nitrogen, storage in a regular deep freezer, and storage in 95% ethanol. All scales which were loosened by the incision were also preserved in 95% ethanol.

Two months after the initial freezing, on 28 September 1998, the fish was taken (still frozen) to Jakarta for the purpose of preservation in formalin. Before preservation, several additional tissue samples were taken from the following areas: white muscle from the area of the ventral incision, red muscle and skin from the medial surface of the left pectoral fin, gill

filaments from the left gill arches, and additional liver samples. Replicates of these tissues were stored in both 100% ethanol and in DMSO-EDTA-NaCl buffer, as described in Seutin et al. (1991).
Before immersing in 10% formalin, the specimen was injected with full-strength formalin in all fins, organs and throughout the body using a large-bore hypodermic needle fitted to a pressure sprayer. After seven weeks of immersion in 10% formalin, the specimen was rinsed well with water and soaked in water for a full day, then transferred into three successively stronger concentrations of ethanol (35%, 55%, and 70%). The specimen is now stored permanently in 70% ethanol in an airtight glass display case.
(13) Condition of preserved specimen: The specimen is generally in excellent condition for morphological investigations. The gill filaments on the left side of the

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Figure 2. The first author's wife Arnaz swimming next to the specimen in approximately 10 m depth. Note the erect position of the first dorsal fin.

fish, as well as the heart and part of the liver have been mostly removed for tissue samples, but otherwise the specimen is intact. Unfortunately, the eggs began to deteriorate before they were injected with full strength formalin.
(14) First literature reference: Erdmann et al. (1998).
(15) Current holding: The specimen is currently housed at the Indonesian Institute of Science's Research and Development Center for Biology in Cibinong, Indonesia (near Jakarta), where it will remain permanently. The specimen was accessioned as specimen # MZB10003. There are plans for a public display of a life-size replica of the specimen at the Bogor National Zoological Museum as well.
CITES import and export permits were obtained for the tissue samples, which are now being stored at the University of California, Berkeley. A schedule for distribution of these limited tissue holdings to qualified coelacanth researchers is currently being prepared.
(16) Additional comments: As commented upon by Erdmann et al. (1998), the only obvious difference between the current specimen and the descriptions of Comoran L. chalumnae is the color. While the Comoran specimens are generally described as steel blue with

white pigment blotches (e.g., Balon et al. 1988), the present specimen was distinctly brown in life, though with a slightly bluish cast to the fin edges and operculum. This color difference may be a result of the deteriorating health of the fish when observed; Comoran coelacanths are known to quickly turn brown in coloration after death.

The other color note of interest was the intense pattern of gold flecks covering the dorsal surface of the body of the specimen. This gold flecking appears to be

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Figure 3. The specimen shortly after death, just prior to freezing.

a result of the prismatic effect of light reflected off the numerous denticles covering the scales of the fish.

Finally, the local name of the fish is 'raja laut', which translates as 'king of the sea' in the Indonesian language. Contrary to the intimation of Forey (1998), however, this name was not previously well-known among the fishing community of north Sulawesi. Rather, this name was actually given to the fish by middlemen fish sellers in an apparent attempt to make the generally inedible coelacanth more marketable to unsuspecting buyers. At the time of the announcement of the discovery of the Sulawesi population, this name was only known to a select few fishermen and fish traders in Manado. Now, thanks to extensive popular media coverage, the name has become a part of the local vernacular.

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for the specimen and tissue, allowed SLJ to fly to Indonesia to lend her expertise in preservation and examination of large fish specimens, and obtained the CITES import permit. The staff of P3B LIPI were most accommodating and helpful in all aspects of the preservation and display process, especially Y. Suhardjono, I. Rachmatika, S. Wirjoatmodjo, R. Hadiaty, Pak

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